

Appendix A

Parameters of the laboratory hot rolling process

Table A-1 The hot rolling parameters for alloy #2

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1165	1050	1225 5 min	1080	1030	990	910	930 5 min	880	930 5 min	890
	out											
t_{ip} (s)		23	--		20	10	13	--		--		--
Gauge (mm)	in	43	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.15	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.43						0.54				
Reduction (%)		76						42				
$\dot{\epsilon}$ (s ⁻¹)		1.67	2.43		3.15	3.92	4.00	4.07		4.00		3.89

Table A-2 The hot rolling parameters for alloy #3

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1162	1043	1225 5 min	1045	1032	980	910	930 5 min	885	930 5 min	890
	out											
t_{ip} (s)		24	--		18	12	18	--		--		--
Gauge (mm)	in	43	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.15	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.43						0.54				
Reduction (%)		76						42				
$\dot{\epsilon}$ (s ⁻¹)		1.67	2.43		3.15	3.92	4.00	4.07		4.00		3.89

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Table A-3 The hot rolling parameters for alloy #4

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1165	1065	1225 5min	1082	1050	1000	910	930 5min	890	930 5min	889
	out											
t _{ip} (s)		22	--		19	14	17	--		--		--
Gauge (mm)	in	43	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.15	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.43						0.54				
Reduction (%)		76						42				
$\dot{\epsilon}$ (s ⁻¹)		1.67	2.43		3.15	3.92	4.00	4.07		4.00		3.89

Table A-4 The hot rolling parameters for alloy #5

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1148	1058	1225 5 min	1081	1020	1010	910	930 5 min	870	930 5 min	885
	out											
t _{ip} (s)		22	--		17	13	23	--		--		--
Gauge (mm)	in	43	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.15	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.43						0.54				
Reduction (%)		76						42				
$\dot{\epsilon}$ (s ⁻¹)		1.67	2.43		3.15	3.92	4.00	4.07		4.00		3.89

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Table A-5 The hot rolling parameters for sample #M1-11 of alloy #6

Pass No		R1	R2	R3	Reheat-ing	R4	R5	R6	Reheat-ing	F1	F2	Reheat-ing	F3
Temperature (°C)	in	1140	1108	1008	1200 5 min	1085	940	901	1200 30 s	925	--	1200 60 s	920
	out												--
t_{ip} (s)		18	22	--		20	--	--		--	--		
Gauge (mm)	in	45	37	30		25	20	15		10	8.3		6.9
	out	37	30	25		20	15	10		8.3	6.9		6
Pass ϵ		0.196	0.21	0.182		0.223	0.288	0.405		0.186	0.18		0.14
Total ϵ		1.50						0.51					
Reduction (%)		78						40					
$\dot{\epsilon}$ (s ⁻¹)		1.82	2.08	2.09		2.56	3.31	4.66		3.05	4.00		3.89

Appendix

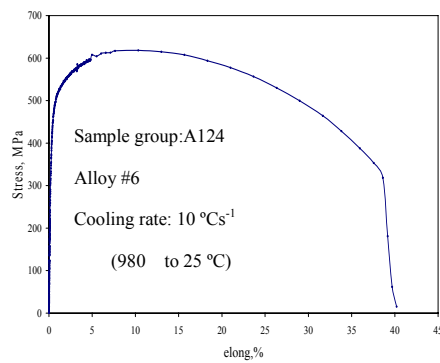
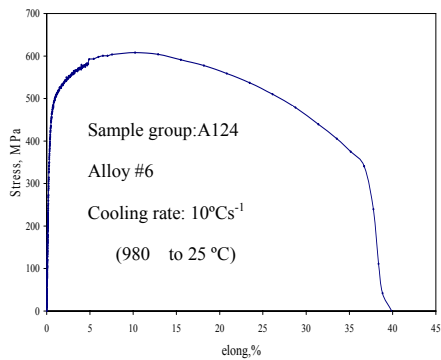
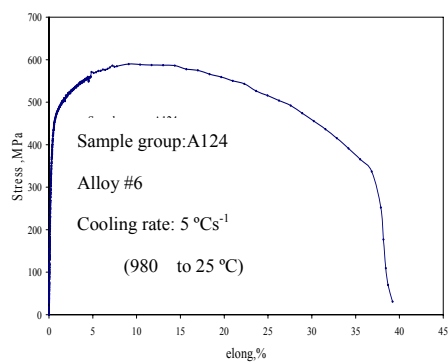
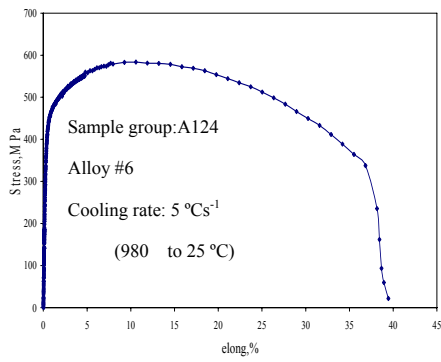
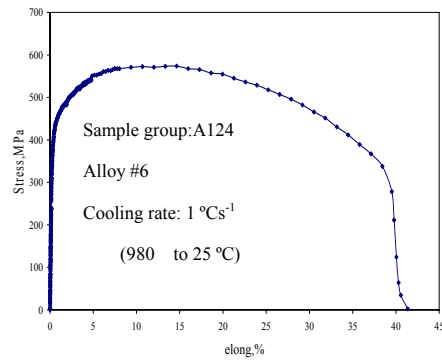
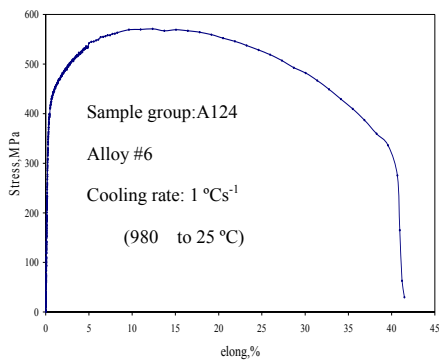
Appendix B
Curves of tensile tests

Conditions on the Gleeble:

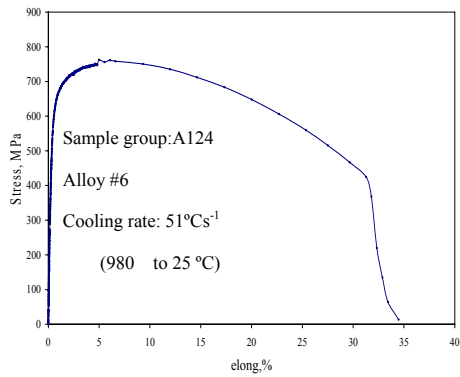
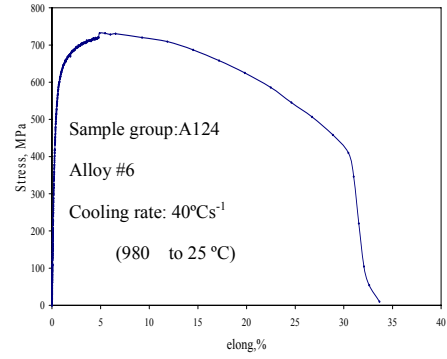
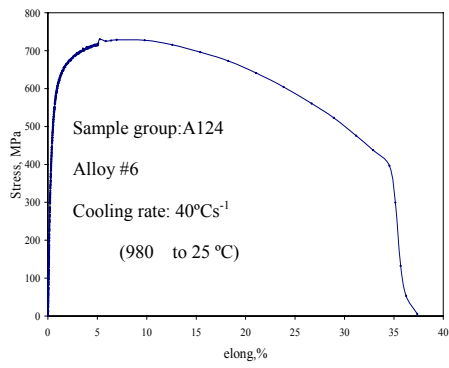
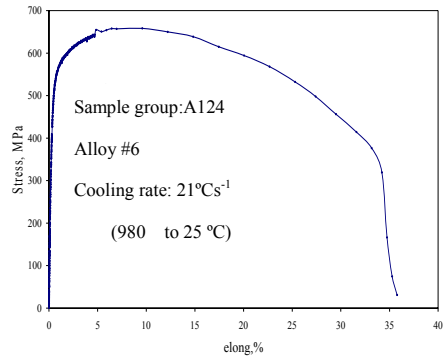
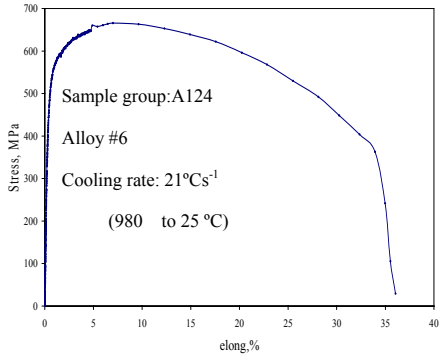
Reheating temperature: 1225 °C

No prior deformation and coiling simulation

Alloy #6



Appendix



Appendix

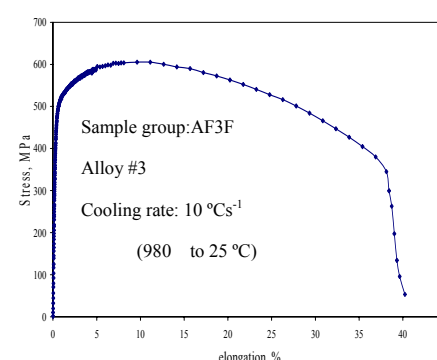
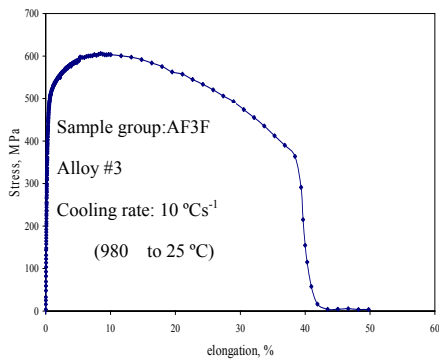
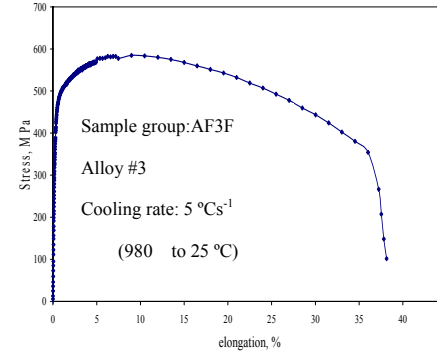
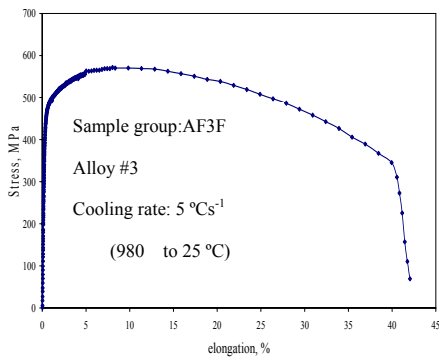
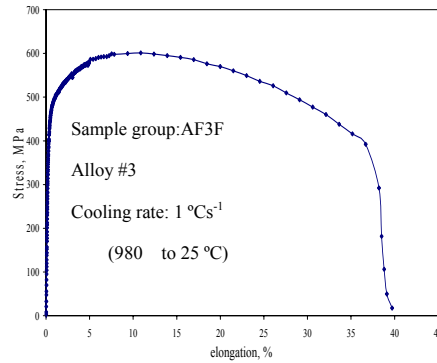
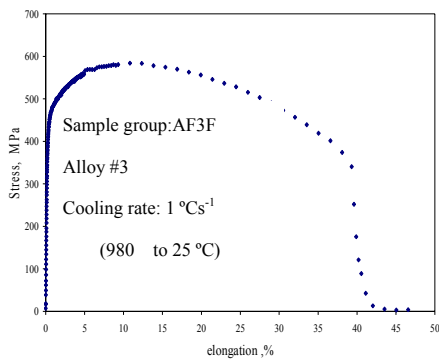
Appendix C
Curves of tensile tests

Conditions on the Gleeble:

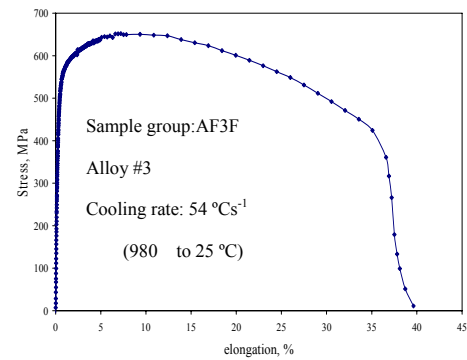
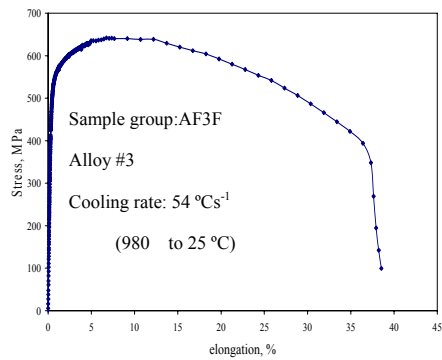
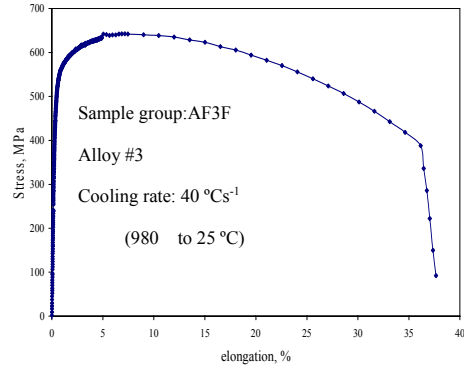
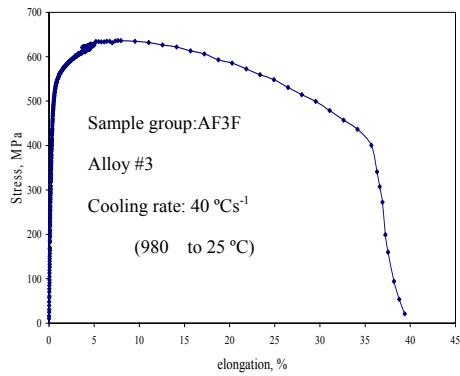
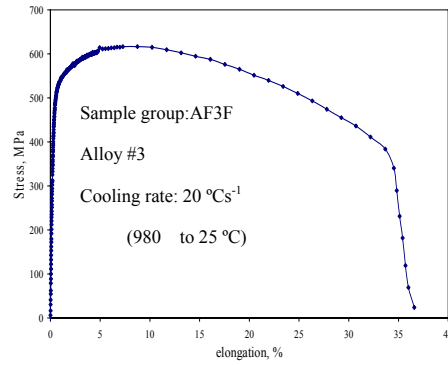
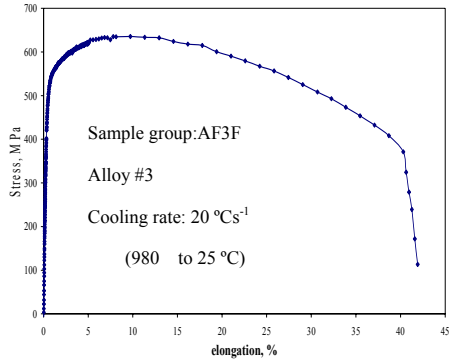
Reheating temperature: 1225 °C

No prior deformation and coiling simulation

Alloy #3



Appendix



Appendix

Appendix D
Curves of tensile tests

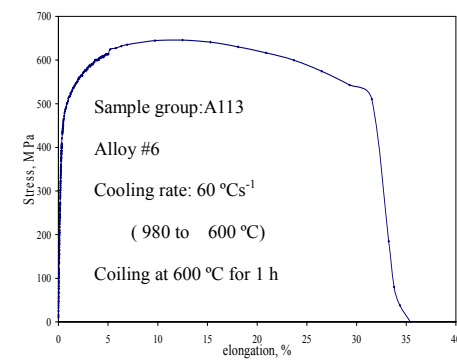
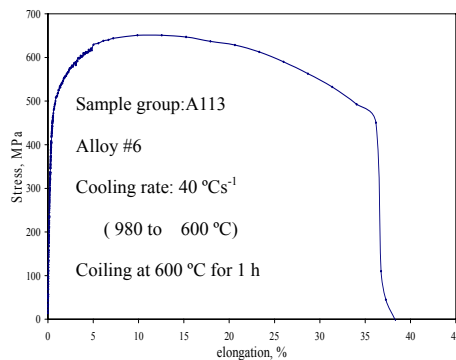
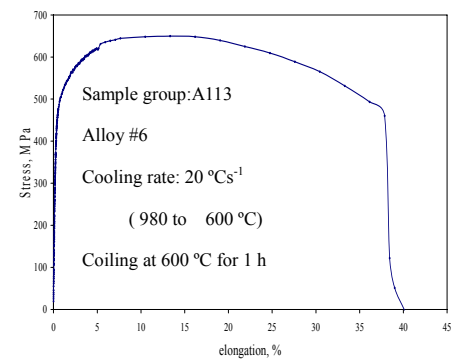
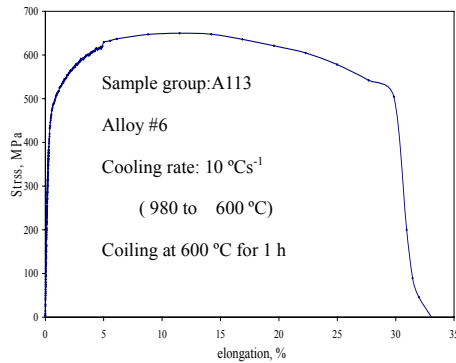
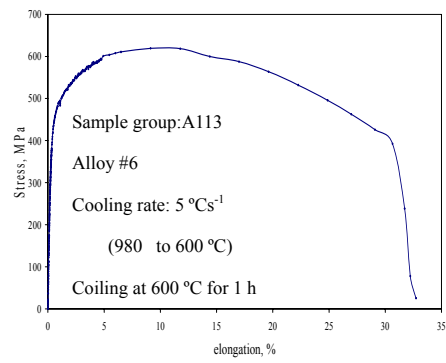
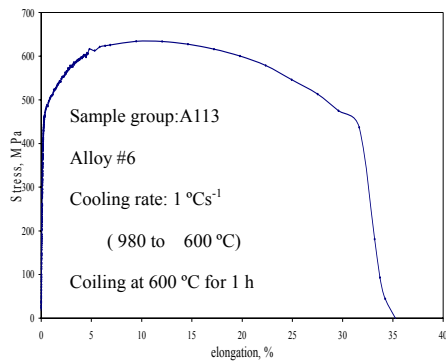
Conditions on the Gleeble:

Reheating temperature: 1225 °C

Coiling at 600 ° for 1 h

No prior deformation

Alloy #6



Appendix E
Curves of tensile tests

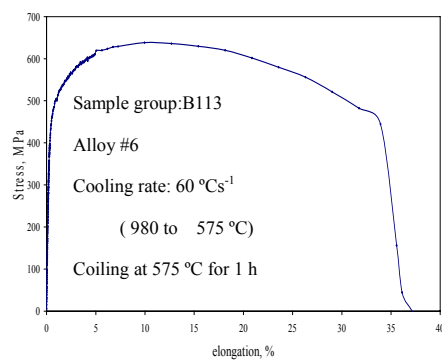
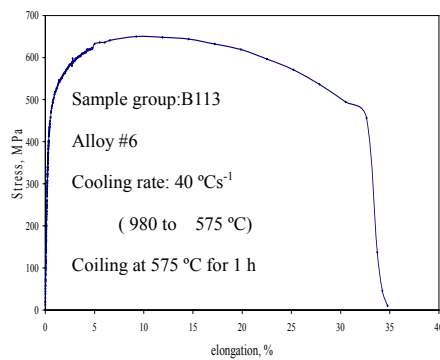
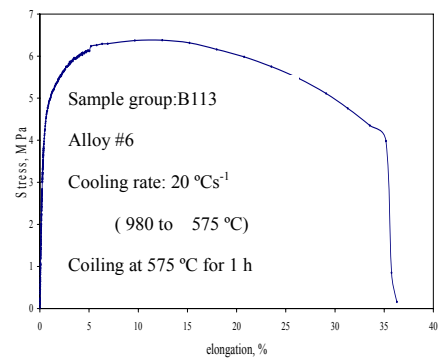
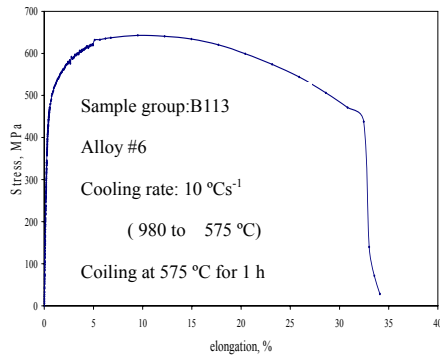
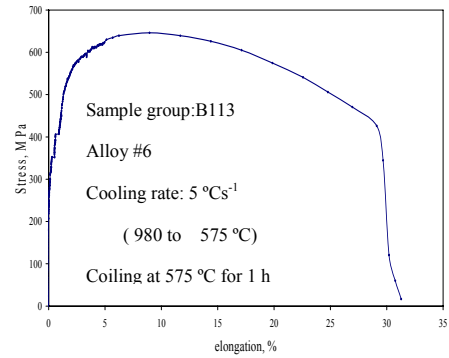
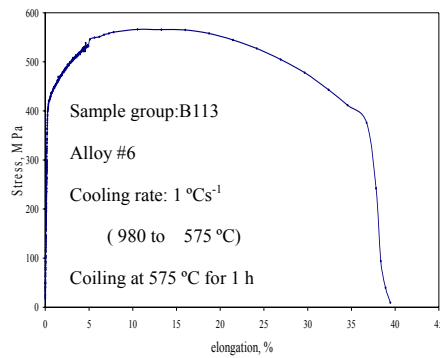
Conditions on the Gleeble:

Reheating temperature: 1225 °C

Coiling at 575 ° for 1 h

No prior deformation

Alloy #6



Appendix F
Curves of tensile tests (Instrumented Hounsfield)

Conditions on the Gleeble:

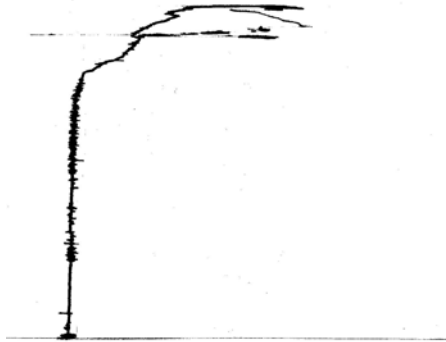
Reheating temperature: 1225 °C

45% and 33% prior deformation in total and below the T_{nr} , respectively

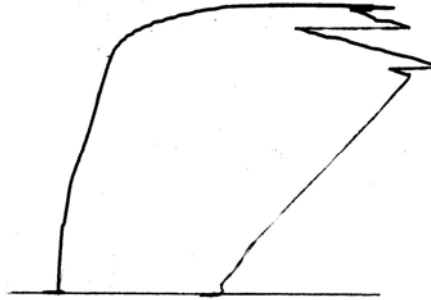
cooling from 860 down to 575 °C

Coiling at 575 ° for 1 h

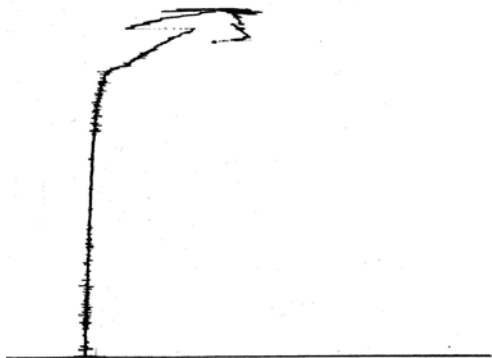
Alloy #6



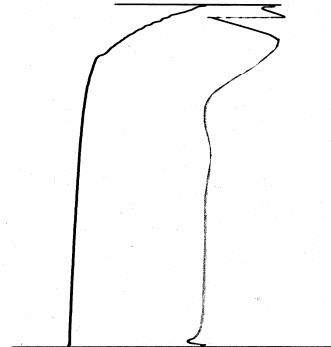
cooling rate : 1 °Cs⁻¹



cooling rate : 1 °Cs⁻¹

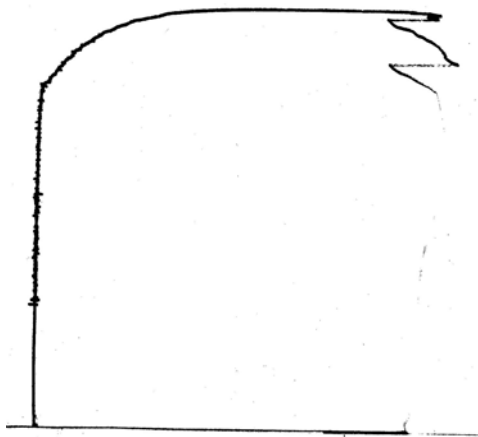


cooling rate : 5 °Cs⁻¹

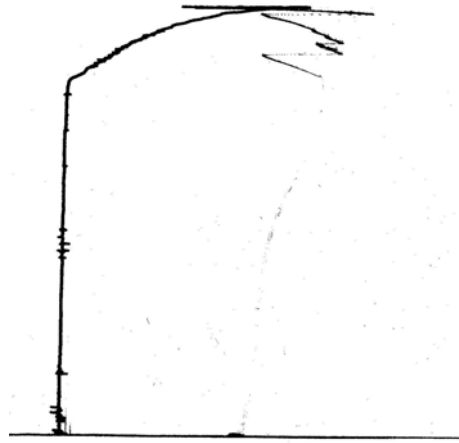


cooling rate : 5 °Cs⁻¹

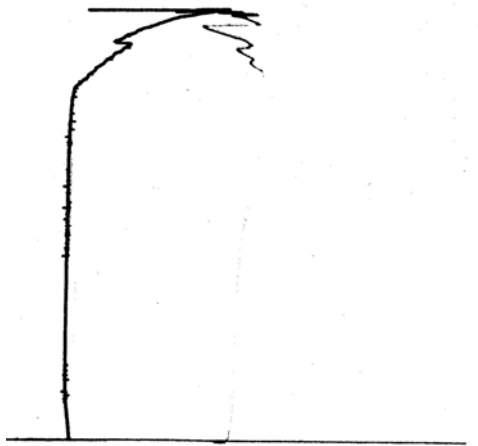
Appendix



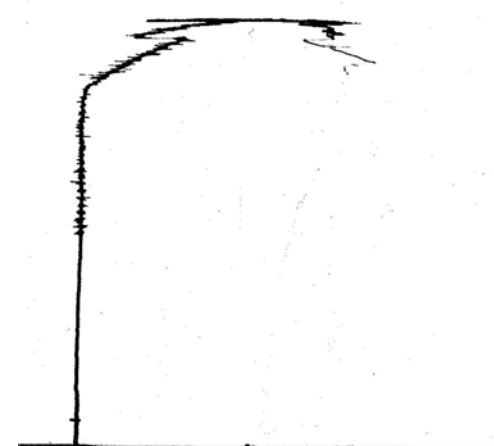
cooling rate : 10 °Cs⁻¹



cooling rate : 10 °Cs⁻¹

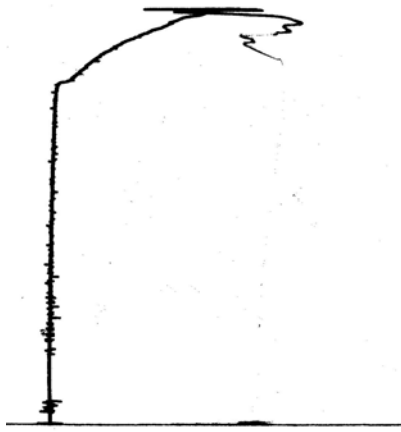


cooling rate : 19 °Cs⁻¹

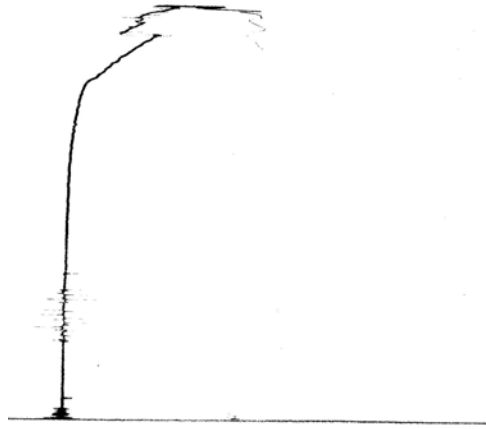


cooling rate : 19 °Cs⁻¹

Appendix



cooling rate : $34\text{ }^{\circ}\text{Cs}^{-1}$



cooling rate : $34\text{ }^{\circ}\text{Cs}^{-1}$

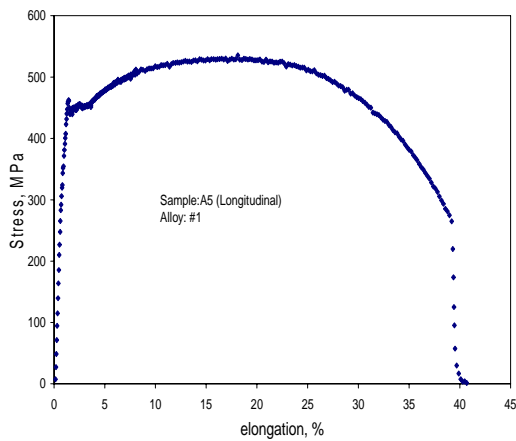
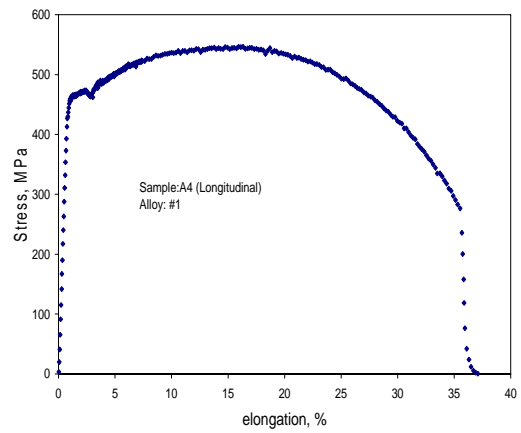
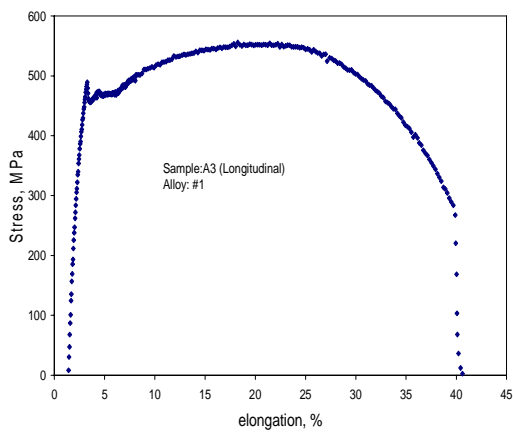
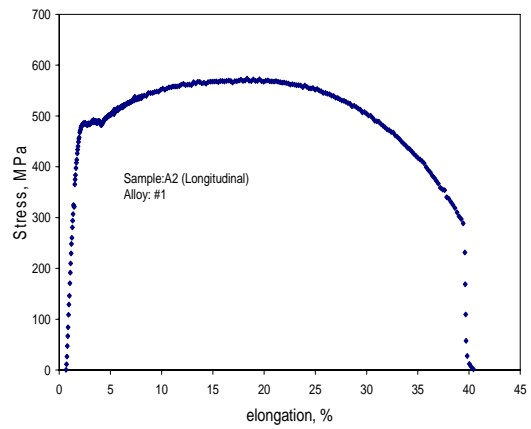
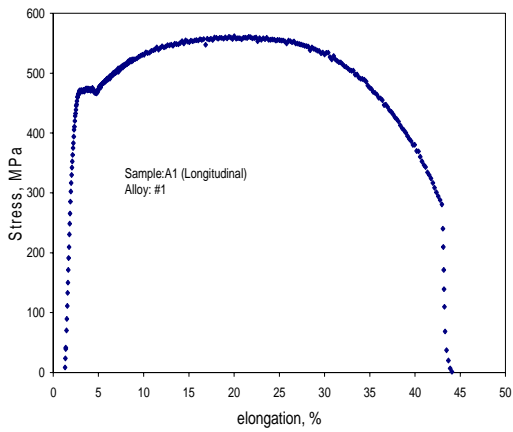
Appendix

Appendix G
Curves of tensile tests

Conditions : all experimental alloys #1 to #5

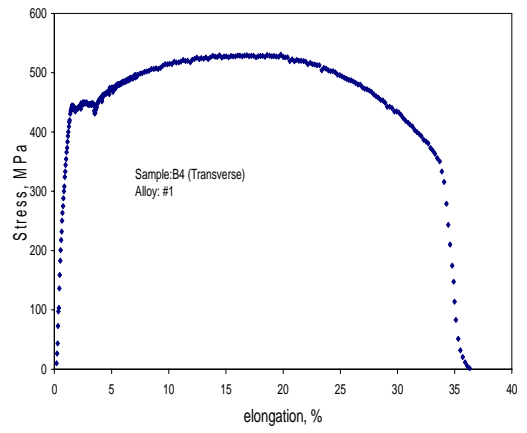
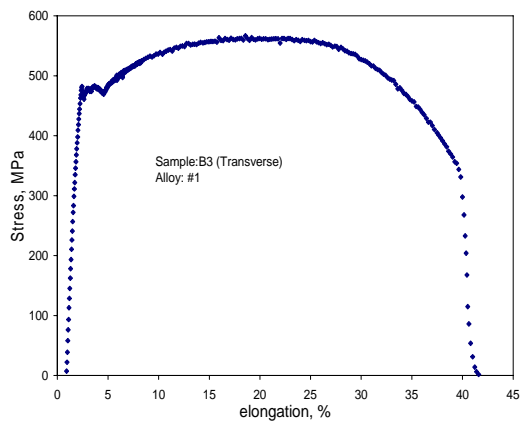
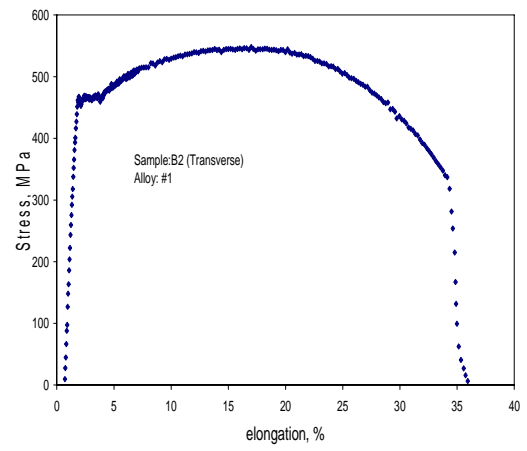
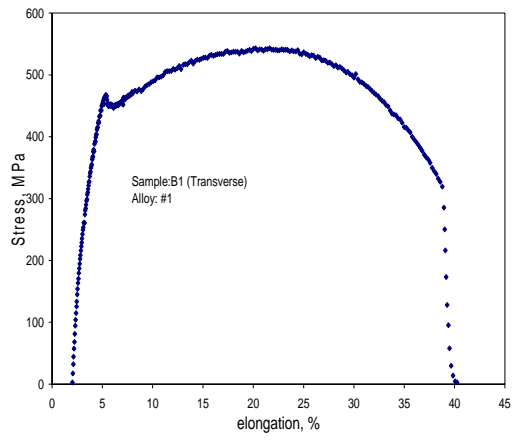
1. Alloy #1:

1.1 Longitudinal specimen:



Appendix

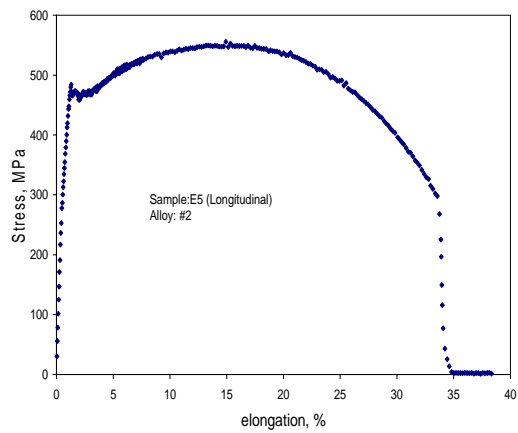
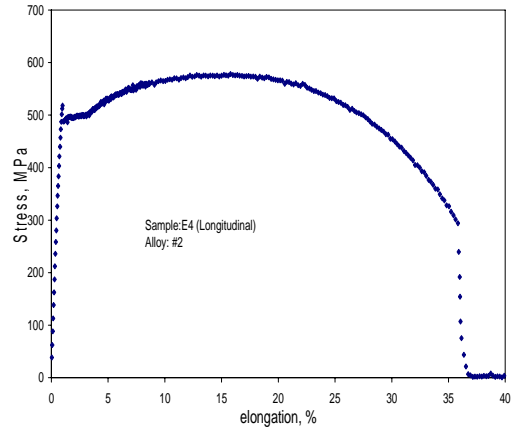
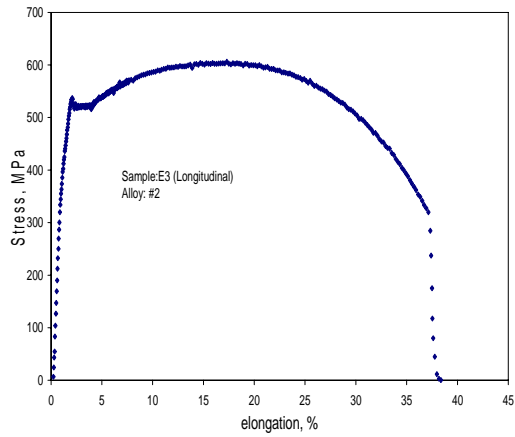
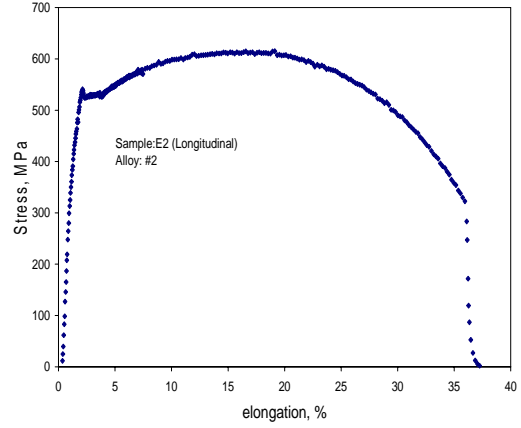
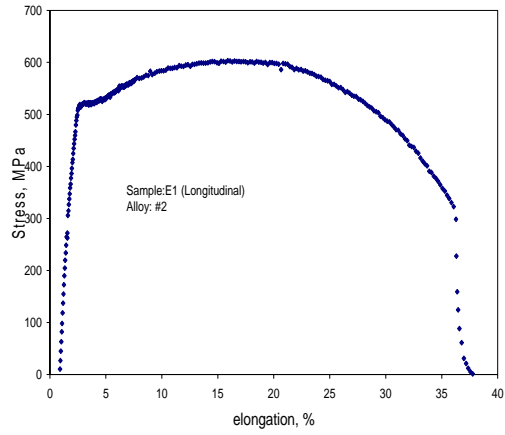
1.2 Transverse specimen:



Appendix

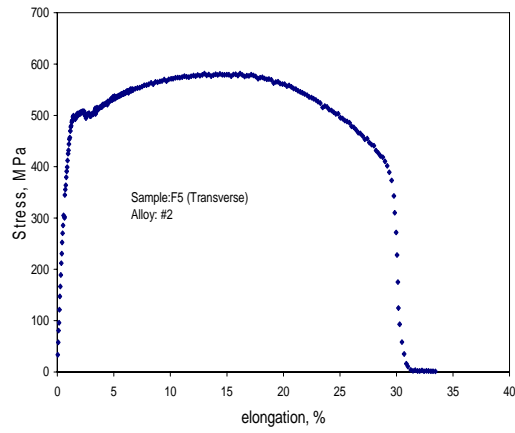
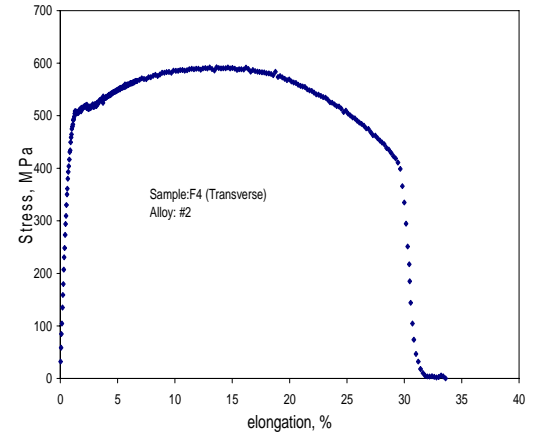
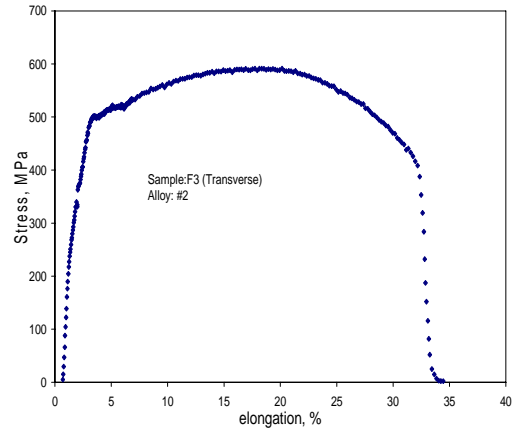
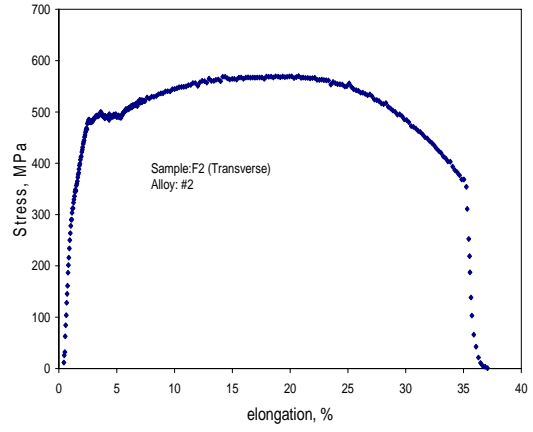
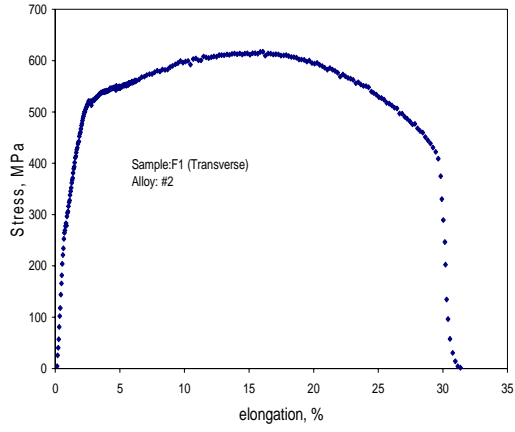
2. Alloy #2:

2.1 Longitudinal specimen



Appendix

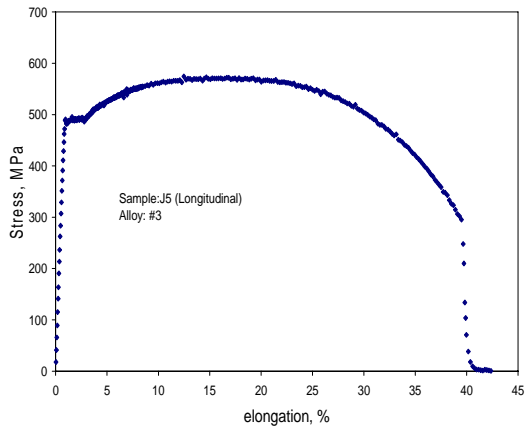
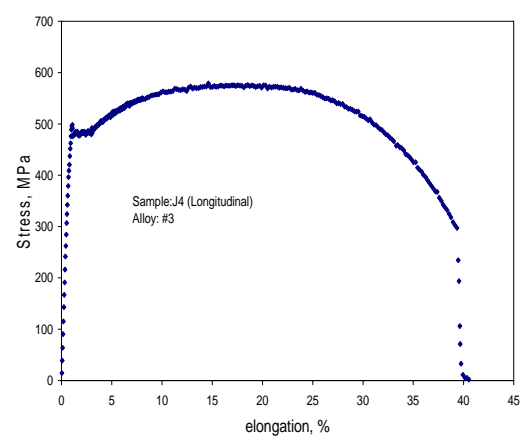
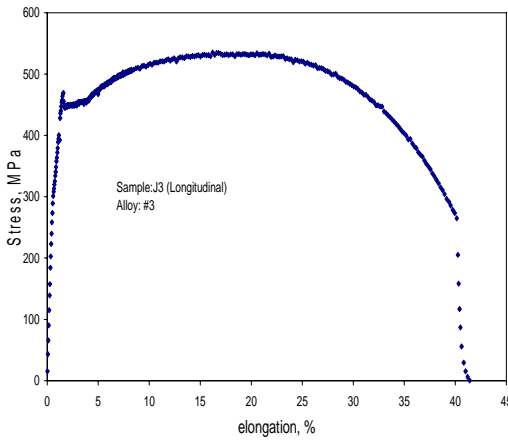
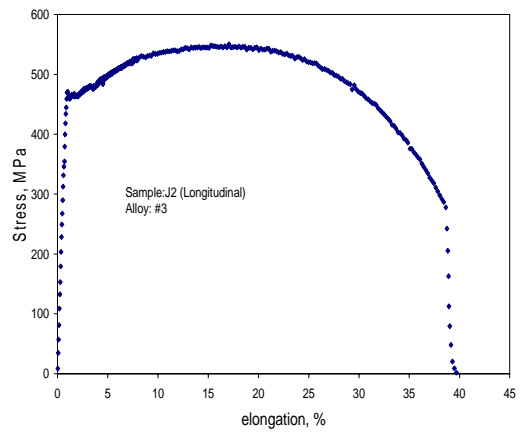
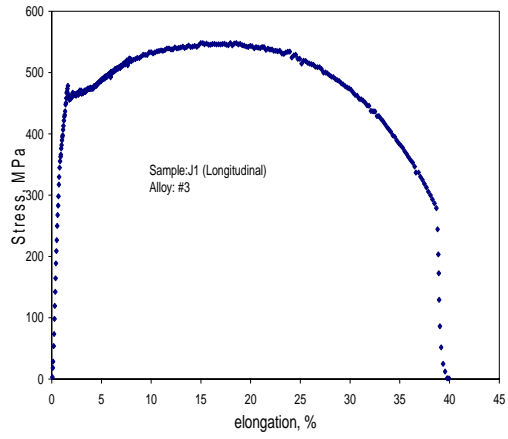
2.2 Transverse specimen:



Appendix

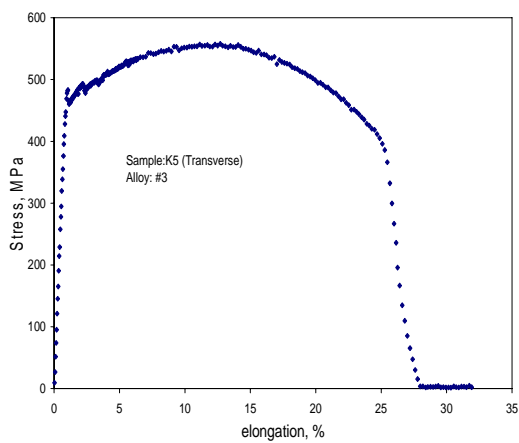
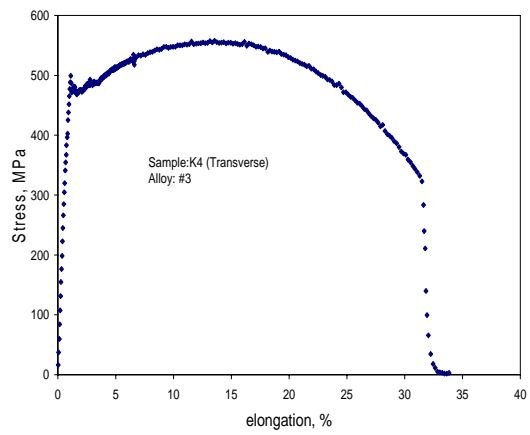
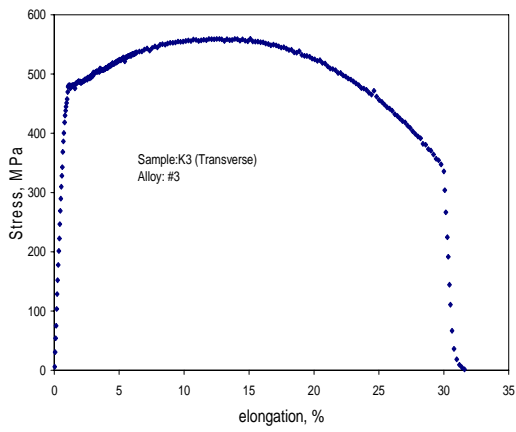
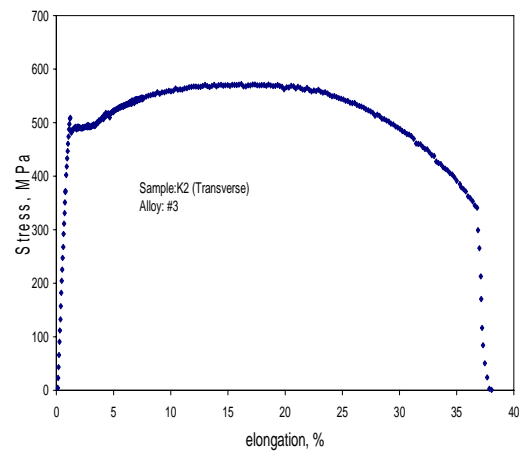
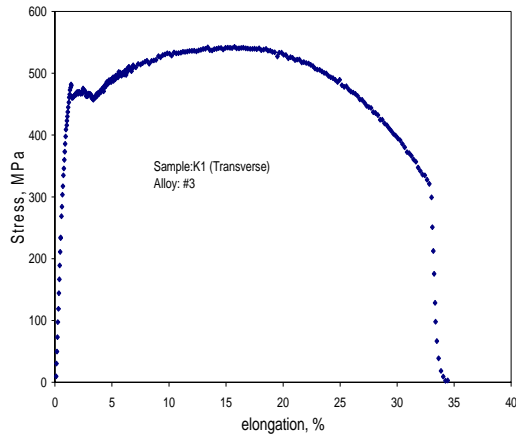
3. Alloy #3:

3.1 Longitudinal specimen:



Appendix

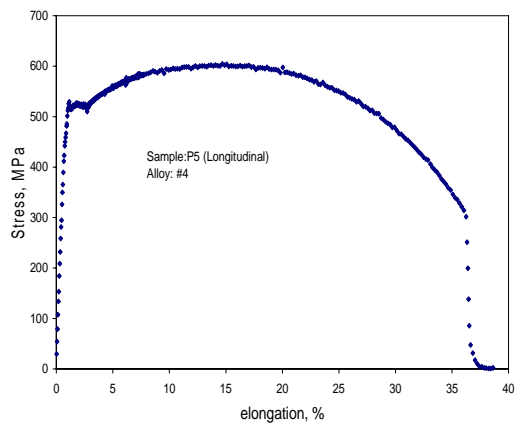
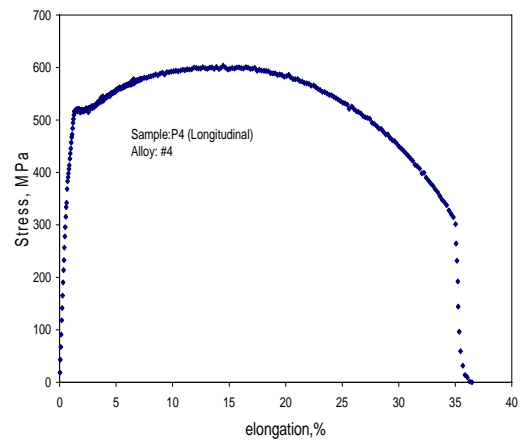
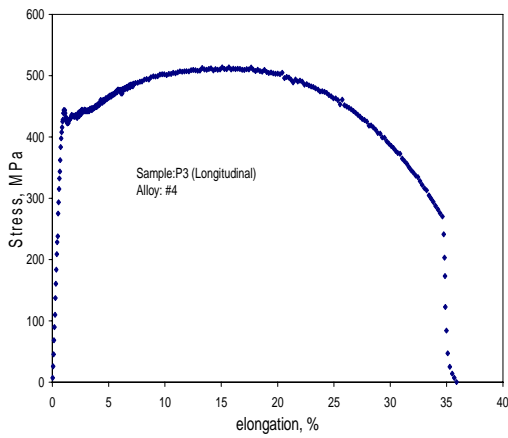
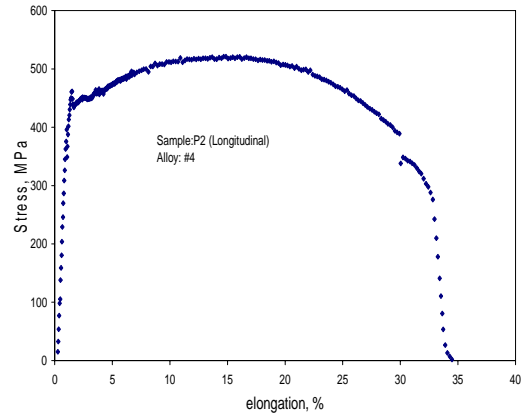
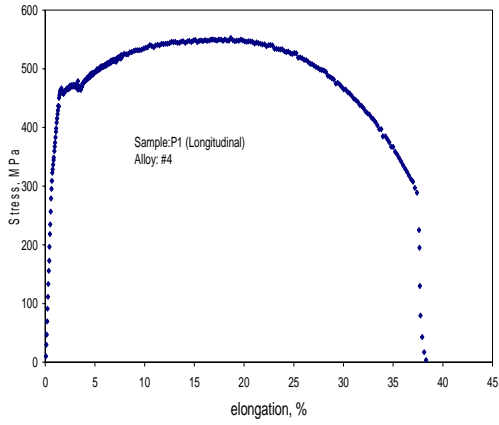
3.2 Transverse specimen:



Appendix

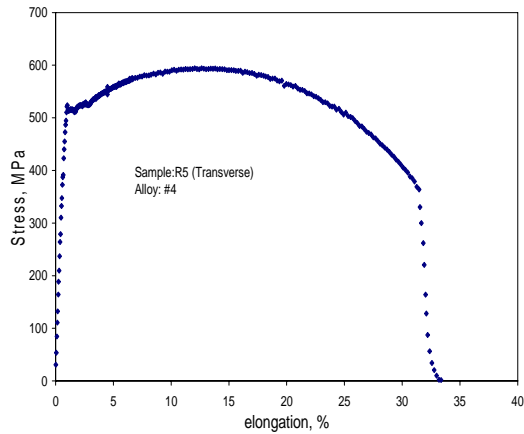
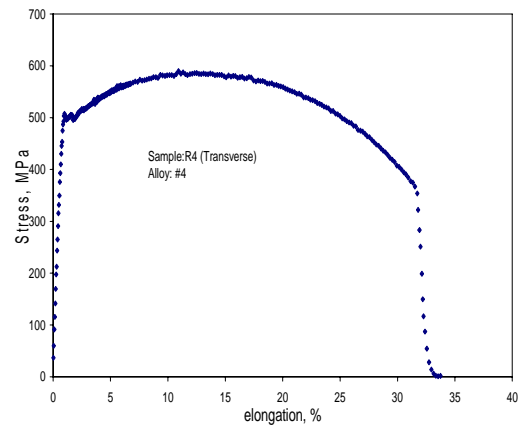
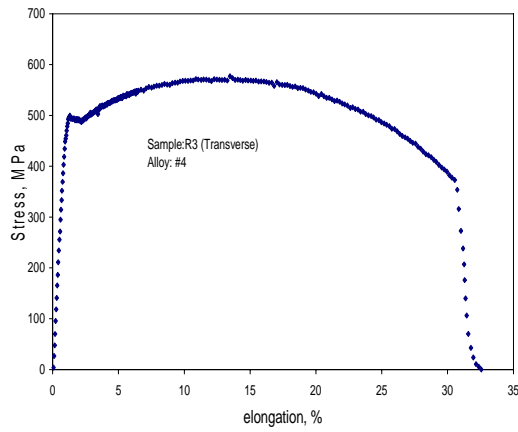
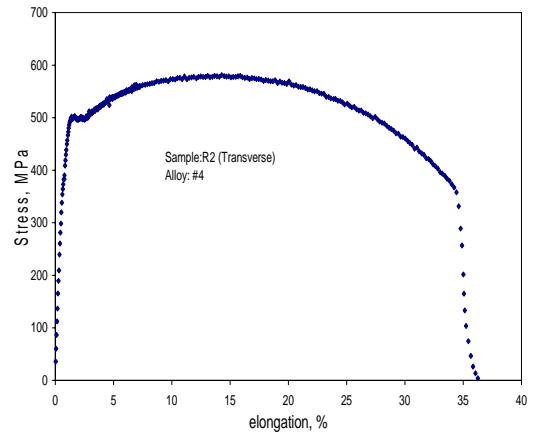
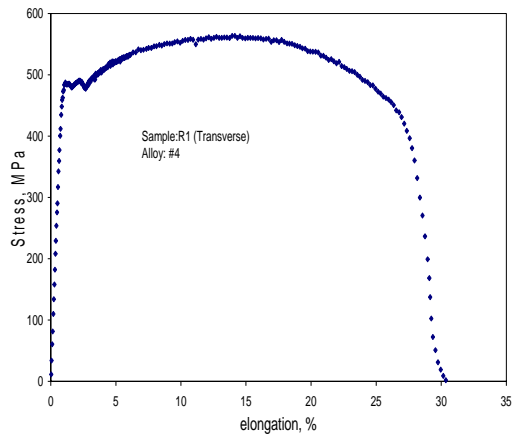
4. Alloy #4

4.1 Longitudinal specimen:



Appendix

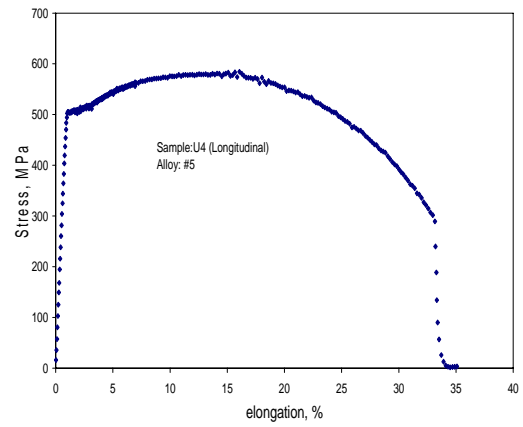
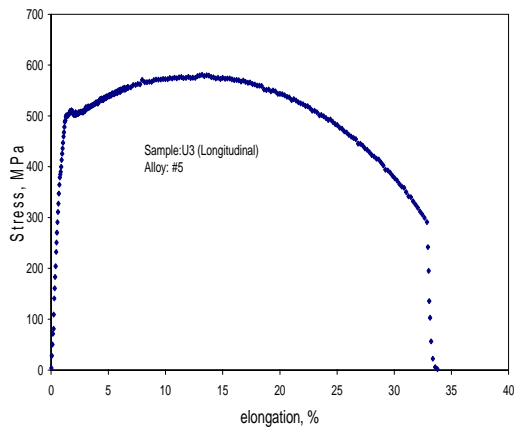
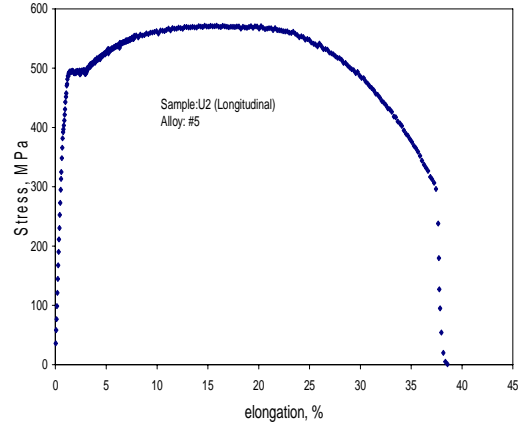
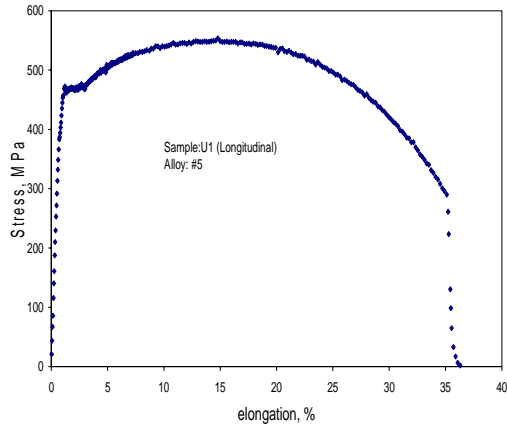
4.2 Transverse specimen:



Appendix

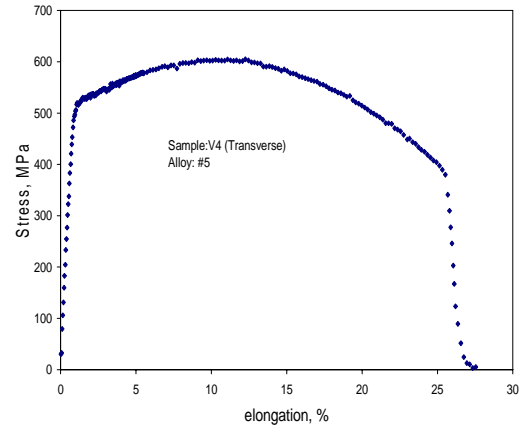
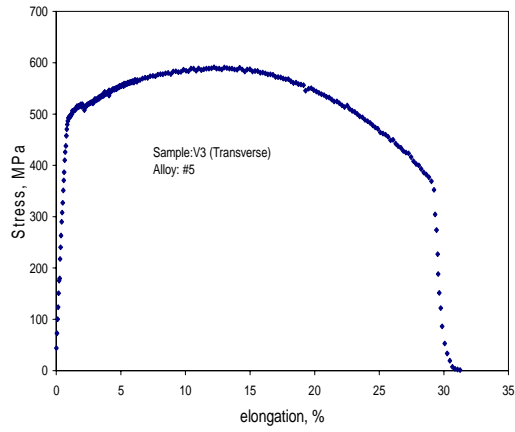
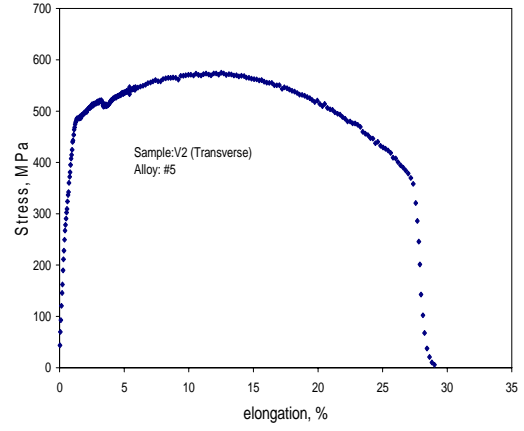
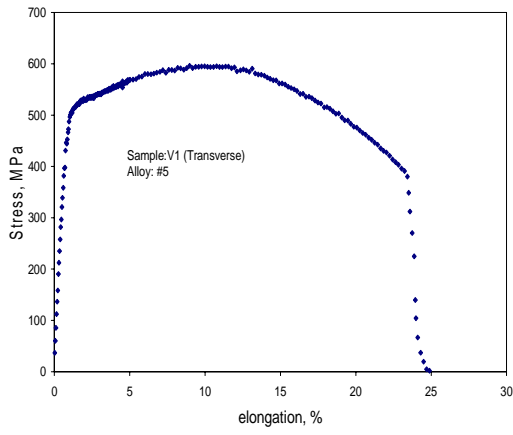
5. Alloy #5

5.1 Longitudinal specimen:



Appendix

5.2 Transverse specimen:



Appendix H

Parameters of the laboratory hot rolling process for tests samples on Gleeble:

Tables H-1 to H-4 show the hot rolling details for the test samples of type A and B for the YS/UTS ratio versus cooling rates, coiling temperatures and deformation values after compression deformation. These coiling temperatures were inadvertently too high. These particular plates were, therefore, not used for the YS/UTS tests directly, but were later used for studying the effect of cooling rate, coiling temperature and prior deformation on the YS/UTS ratio on the Gleeble (see section 6.9.2).

Table H-1 The laboratory hot rolling parameters for sample #A124 of the Mo-free reference alloy #6

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1132	1075	1225 5 min	1157	1112	1058	910	930 5 min	870	930 5 min	880
	out											
t_{ip} (s)		26	--		18	32	58	--		--		--
Gauge (mm)	in	45	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.196	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.48						0.54				
Reduction(%)		77						42				
$\dot{\epsilon}$ (s ⁻¹)		1.82	2.43		3.15	3.92	4.00	4.07		4.00		3.89

Reheating: 1220 °C for 60 min

Fast cooling: 35 °Cs⁻¹ (860 down to 650 °C)

Coiling: 650 °C for 24 hrs

Appendix

Table H-2 The laboratory hot rolling parameters for sample #AF3F of alloy #3 (with 0.09% Mo)

Pass No		R1	R2	reheating	R3	R4	R5	F1	reheating	F2	reheating	F3
Temperature (°C)	in	1170	1060	1225 5 min	1120	1070	1000	910	930 5 min	890	930 5 min	880
	out											
t_{ip} (s)												
Gauge (mm)	in	43	37		28	20	13.6	10.3		8.3		6.9
	out	37	28		20	13.6	10.3	8.3		6.9		6
Pass ϵ		0.15	0.28		0.34	0.38	0.28	0.22		0.18		0.14
Total ϵ		1.43						0.54				
Reduction(%)		76						42				
$\dot{\epsilon}$ (s ⁻¹)		1.67	2.43		3.15	3.92	4.00	4.07		4.00		3.89

Reheating: 1225 °C for 60 min

water quench down to room temperature

Table H-3 The laboratory hot rolling parameters for sample #A113 and B113 of the Mo-free alloy #6

Pass No		R1	R2	R3	Reheat-ing	R4	R5	R6	Reheat-ing	F2	F2	Reheat-ing	F3
Temperature (°C)	in	1141	1096	1013	1200 5 min	1119	1049	1002	925 5 min	880	840	925 5 min	870
	out												
t_{ip} (s)		10	20	--		15	15	--		10	--		--
Gauge (mm)	in	45	37	30		25	20	15		10	8.3		6.9
	out	37	30	25		20	15	10		8.3	6.9		6
Pass ϵ		0.196	0.21	0.182		0.223	0.288	0.405		0.186	0.18		0.14
Total ϵ		1.50						0.51					
Reduction(%)		78						40					
$\dot{\epsilon}$ (s ⁻¹)		1.82	2.08	2.09		2.56	3.31	4.66		3.05	4.00		3.89

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Reheating: 1178 °C for 60 min

Fast cooling: 29 °Cs⁻¹ (840 down to 640 °C)

Coiling: 640 °C for 24 hrs

Table H-4 The laboratory hot rolling parameters for sample #TEN06 of the Mo-free alloy #6

Pass No		R1	R2	R3	Reheat -ing	R4	R5	R6	Reheat -ing	F2	F2	Rehea t-ing	F3
Tempera- ture (°C)	in	1135	1026	968	1200	1040	980	940	1200	870	820	1200	840
	out				5 min				30 s			60 s	820
t _{ip} (s)		15	18	--		15	13	--		14	--		--
Gauge (mm)	in	45	37	30		25	20	15		10	8.3		6.9
	out	37	30	25		20	15	10		8.3	6.9		6
Pass ε		0.196	0.21	0.182		0.223	0.288	0.405		0.186	0.18		0.14
Total ε		1.50						0.51					
Reduction(%)		78						40					
ε̇ (s ⁻¹)		1.82	2.08	2.09		2.56	3.31	4.66		3.05	4.00		3.89

Reheating: 1178 °C for 60 min

Fast cooling: 33 °Cs⁻¹ (820 down to 620 °C)

Coiling: 620 °C for 24 hrs